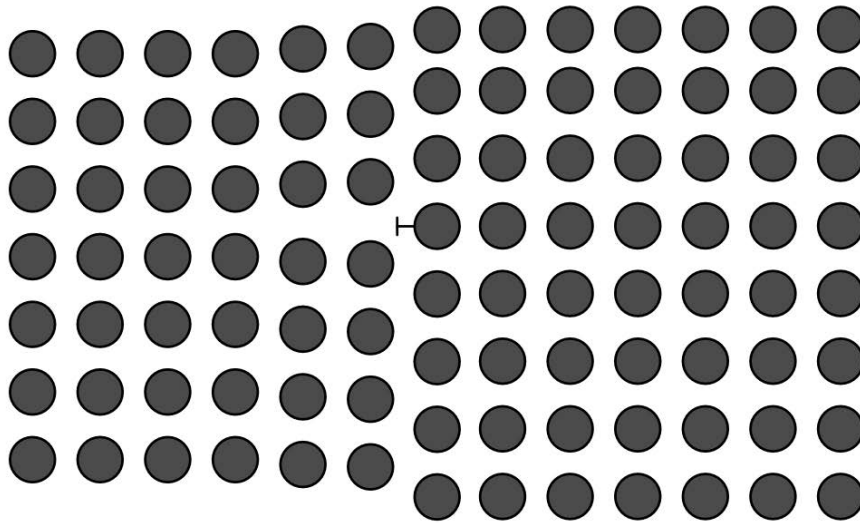


1 Line defects

In addition to point defects, crystals can have defects that cover larger areas and involve the coordination of more atoms than just one. Point defects are called 0D, or zero dimensional; in keeping with this nomenclature, line defects can be thought of as 1D defects (involving a line of atoms), and planar defects can be thought of as 2D defects (involving a plane). One important line defect is called a *dislocation*. A dislocation amounts to an extra line of atoms which persists part of the way through the crystal: the termination within the crystal is noted with a T shape as below:

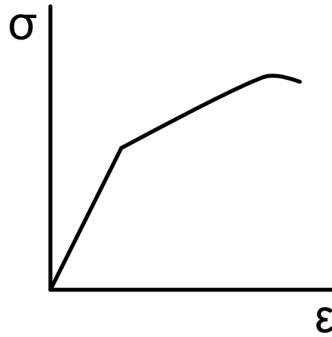


The bulk of the crystal maintains its equilibrium structure, well-aligned with the lattice. However, you can see that the region around the origin of the dislocation has been forced out of its equilibrium position in the lattice. The spacing between atoms is different around the end of the dislocation; the bonds are disrupted. It takes energy to generate a dislocation, but it also takes energy for it to move in the crystal. Therefore, even though they are not the most energetically favorable state, they are meta-stable in equilibrium once generated.

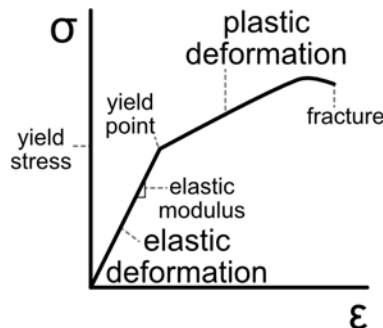
2 Mechanics and stress–strain curves

One of the most informative experiments to explore the mechanical properties of a material is generating a stress–strain curve. As we discussed in lecture, this is usually done with an Instron; the basic principle is to pull (or push) on a material in a carefully controlled way, and to measure its response.

Example: Label the plot with the following features of stress–strain curves: elastic deformation, plastic deformation, yield stress, elastic modulus, yield point, fracture



Elastic deformation refers to the linear response of a material to applied strain. This typically happens for low amounts of applied stress in crystalline materials. The slope of the stress-strain curve in the elastic region is called the *elastic modulus*. *Plastic deformation* refers to nonlinear strain response that is irreversible. The transition between elastic and plastic deformation is the *yield point*, and the stress at which the material yields is the *yield stress*. When the material is not able to stretch any more, it breaks: this is *fracture*. The relevant regimes are labeled below:



3 Slip

Even failure in crystalline materials is systematic: when significant force is applied to a material, enough to break bonds, the material can yield. Except in cases of high impact, this generally happens along *slip planes*. Slip planes are the most densely-packed planes in a lattice. Since the bond density within a slip plane is as large as it gets in the crystal, the out-of-plane density is lower: this means that fewer bonds must be broken for rows of atoms to move past each other as the material yields. As it yields, you can think of a planar face dividing sections of material forced in different directions. The directions that slip happens along are called *slip directions*, and with similar rationale, they are the most closely-packed directions in the crystal.

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